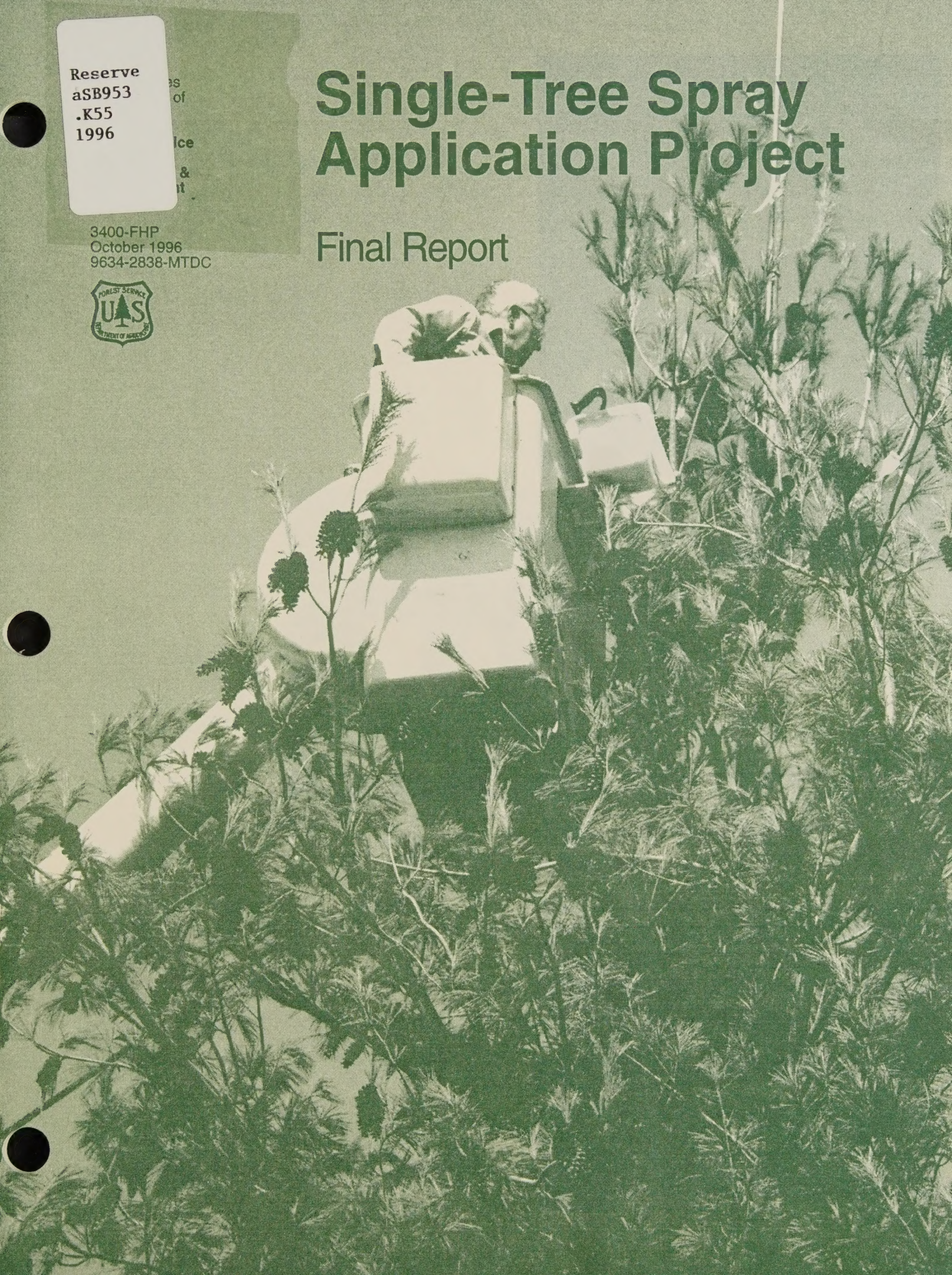
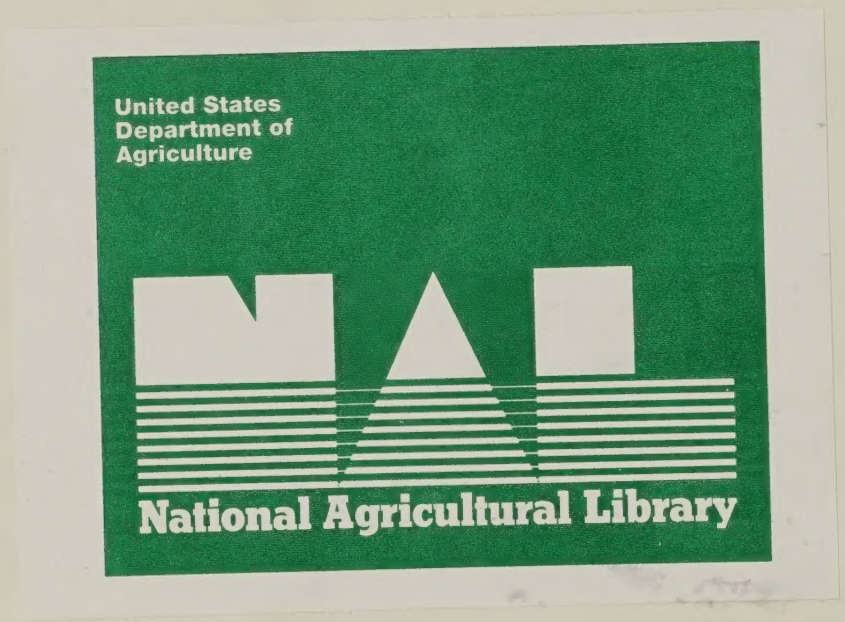
Single-Tree Spray Application Project

Final Report

3400-FHP
October 1996
9634-2838-MTDC

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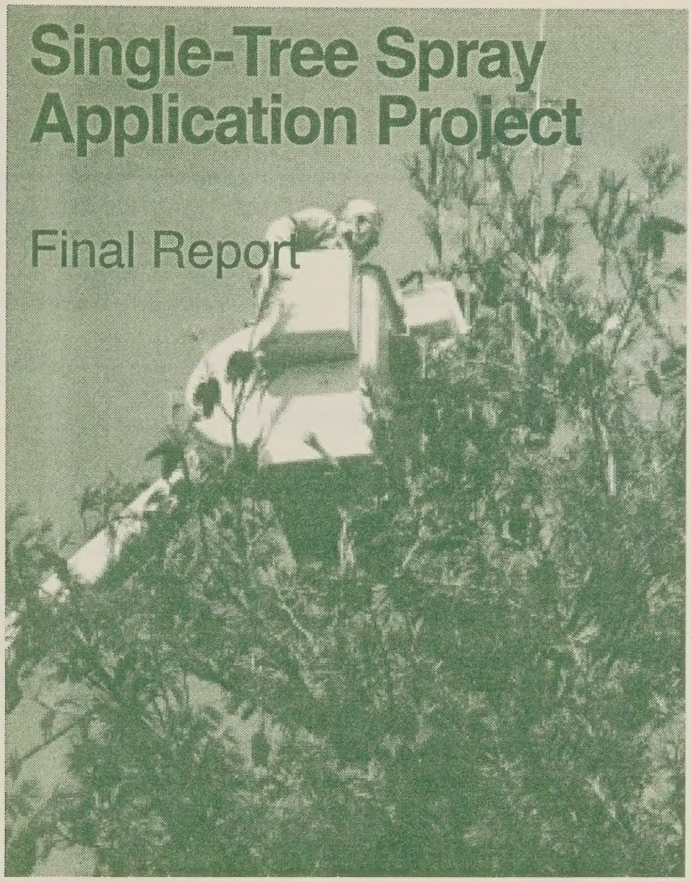


Bill Kilroy
Engineering Technician

Dave Rising
Mechanical Engineer

Harold Thistle
Program Leader

USDA Forest Service
Technology & Development Program
Missoula, Montana

5E52P64–Single-Tree Spray Systems

October 1996

Contents

Introduction

The Missoula Technology and Development Center (MTDC) has worked with the Forest Health Technology Enterprise Team (FHTET), and others to design a sprayer system that protects specific trees in both nurseries and wild stands. Forest Service tree improvement specialists have identified individual trees exhibiting a heightened resistance to specific insects or disease. FHTET wanted to develop a sprayer system that would economically protect these specific trees from cone beetles and other insects. They wanted a method that would release less chemical than aerial application, one that minimized spray drift and worker exposure to hazardous chemicals, yet gave complete coverage to the target trees.

In 1993 single-tree sprayer systems were developed by MTDC staff working with Washington Office Forest Health Protection (WOFHP), Pacific Southwest Forest and Range Experiment Station (PSW), and Region 5 (Pacific Southwest) Forest Health Protection (FHP) personnel. These systems were designed with either a single full-circle sprinkler head at the top (Figure 1), or with additional heads located below in the crown. The top head is positioned above the crown of the tree on a rigid polyvinyl chloride (PVC) pipe column secured to the trunk of the tree. Flexible polyethylene (Poly) pipe leads from the rigid PVC down the tree to the orchard floor (Figure 2). A garden hose coupling (located beyond the spray head radius) provides a safe connecting point. Personnel using a tractor-mounted tank and pump unit can hook up to the single-tree system, spray the tree, drain the pipe and disconnect the coupling without exposing themselves to the insecticide.

Three prototype systems were field tested in Central California with mixed results. Changes were made to the design, and in 1994-1995 the Center collaborated with the Coeur d'Alene Forest Service Nursery, Coeur d'Alene, ID, in a study comparing the single-tree system with the hydraulic sprayer currently used by that nursery. Ten single-tree units were installed in Coeur d'Alene's tree improvement orchard during this test (Herzberg 1995).

Single-tree sprayer systems were also placed in seven trees at Lookout Pass on the Montana-Idaho border. The purpose of this test was to determine the durability of the systems in a harsh environment (5000 feet above sea level), but no monitoring has been reported since then.

Figure 1—A single sprinkler head positioned at the top of a tree.

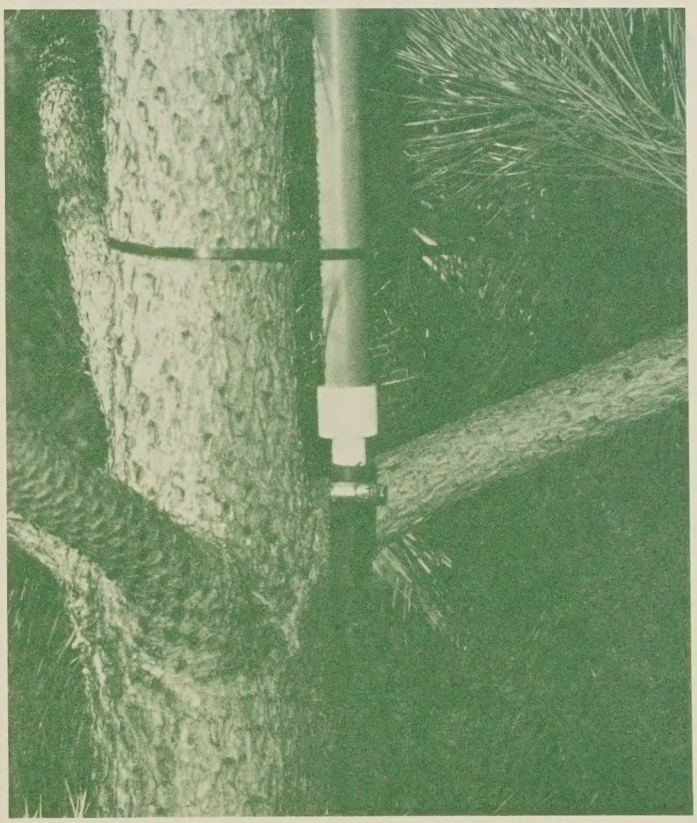


Figure 2—Lower end of rigid PVC showing attachment to flexible pipe.

Installations

In early spring of 1995, MTDC staff traveled to the Oconto Seed Orchard, Antigo, WI, and the Beech Creek Seed Orchard, Murphy, NC. At both sites they assisted nursery personnel in assembling and installing the single tree sprayer systems in nursery trees. At Beech Creek, 20 systems were installed, while at Oconto, 40 trees were outfitted with the necessary plumbing. Representatives of Weyerhaeuser Company observed the installation process at Beech Creek and were interested in the systems.

At both orchards changes were made to overcome logistical problems. Metal pipe such as EMT electrical conduit is rigid, capable of withstanding harsh environmental conditions, and readily available. It was not used because of the probability of attracting lightning strikes. Different nozzles with a range of flow ratings were investigated. Although pop-up sprinkler heads were used in some earlier installations, they were replaced with less expensive heads in later systems.

Different methods of attaching the rigid plumbing to the tree were tried. Television antenna lead-in standoffs were chosen to avoid girdling the trees (Figure 3). These are cheaper than eyebolts, and they are made of lighter metal that can be more easily formed around the pipe. In-line strainers were deemed necessary to protect the nozzles as were plugs to seal the bottom hose thread end of the system from insects and orchard floor debris. Plastic cap plugs were located to do this quite easily when the male half of a common garden hose quick-disconnect unit is left attached to the Poly pipe at the bottom of the tree.

The trees at Beech Creek were 50 to 55 ft tall; the trees at Oconto were 35 ft tall. The spray system nozzles were positioned 2 ft above the treetops. A bucket truck was used when installing systems at Beech Creek; two self-propelled lifts were used at Oconto.

Two men went up in the buckets to attach the spray equipment to the tree, a helper remained on the ground to hand pipe to the men in the lifts. It took about 15 minutes to

Figure 3—Attachment of rigid PVC to tree trunk using a standoff and hose clamp.

fasten the rigid piping properly to each tree. More time was actually spent repositioning the lifts than was spent installing the system.

A check valve to the atmosphere off of a T-fitting just under the sprinkler head was tested on one system at the Oconto. It was felt that this would reduce drainback time. After it was determined that the slow drainback time was really caused by siphoning circulation at the pump tank, and the tank plumbing changed, no check valves were used.

Larry Barber of Region 8 (Southern) State and Private Forestry—Forest Health, Asheville, NC, stated that the single-tree sprayer systems in the Beech Creek Orchard allowed that orchard to control the white pine cone beetle for the first time. He reported no leaks in the system fittings, and no problems with the quick disconnects. There were also no blockages in the systems from foreign objects such as insects. Barber found no wind or weather damage to any of the installed systems.

He did point out that personnel were still exposed to insecticide contact. This contact was due to drift while spraying. The personnel were positioned on the wrong side of the tree. He stated that 10 mph was the wind speed restriction (when the spray operation would be shut down) at Beech Creek.

Barber also noted that tree growth may pose a problem unless nozzles with a wider coverage radius were used in the future.

Bill Sery at Oconto said that last winter had been a bad one with substantial orchard damage, yet he had observed no weather damage to any of the 40 single tree sprayer systems. One upper section of rigid pipe had come loose from the antenna standoff holding it to the tree trunk. The unit remained in place and no damage was done to any of the plumbing. That particular standoff may not have been crimped as tightly around the pipe as the others. It may have released as the tree flexed in the wind. There are two standoffs on each tree system.

The sprinkler systems were used to control severe damage caused by the white pine cone beetle, *(Conophthorus coniperda)*, and the white pine cone borer, *(Eucosma tocullionana)*. Sery reported:

> *"Three applications of Asana XL were made in 1995 and three in 1996. 9.6 ounces of Asana XL were diluted in 100 gallons of water. Then 10 gallons spray solution were applied to each tree. The process was rather time consuming, requiring 1–1.5 days per application.*
>
> *The results look encouraging. Only minimal winter damage was sustained during a very tough winter. Infestation tallies performed in 1995 showed an improvement in sprayed versus non-sprayed trees. This year we are looking forward to harvesting a significant cone crop from treated trees whereas previously we had met with much frustration."* —See Appendix C for a complete copy of Bill Sery's report.

General Guidelines

Although there is great opportunity for creativity in these systems, MTDC staff has some recommendations for a place to start. The specific items in the final equipment configuration should work well, but not to the exclusion of other equally satisfactory products.

Common plastic lawn sprinkler heads seem to do a good job and are readily available, lightweight, and inexpensive. An integral strainer is important, but "pop-up" heads are unnecessary and more expensive. Also, they are heavier, which is undesirable. On windy days when a heavy head whips back and forth, it might cause a problem where the pipe is attached to the tree.

Both rigid PVC and flexible Poly plastic pipe are relatively inexpensive and readily available in common weights and sizes. However, this is not necessarily true if you want heavier wall thickness, or sunlight resistance. For availability, we recommend staying with standard weight, Schedule 40 or equivalent PVC pipe. To get sunlight resistance, we recommend using plastic electrical conduit with UV protection built-in. The $^{3}/_{4}$-in diameter conduit is more rigid than $^{1}/_{2}$-in diameter conduit, but the larger conduit requires one additional fitting and holds more liquid. If you are concerned about drainback time affecting productivity, consider using $^{1}/_{2}$-in conduit. In doing so, you will use one less plastic pipe fitting per tree and the TV antenna standoffs will fit with less work.

While plastic water pipe comes in both 10-ft and 20-ft lengths, plastic electrical conduit is only readily available in 10-ft lengths. However, this does not seem to be a problem. With the sprinkler head positioned 2 ft above the tree's leader, the upper TV antenna standoff should be placed as high as possible on the stem. The small diameter metal of the standoff allows it to be screwed by hand into the tree stem higher in the tree, where the stem is only an inch or so in diameter. Locate the lowest standoff several feet above the bottom of the rigid conduit. This will enable the head to be raised that distance, to clear new growth, by just slipping the pipe upwards. To keep the pipe from slipping down through the standoffs, tighten a hose clamp around the rigid conduit just above one or both of the standoffs.

Plastic pipe fittings are available to connect almost any combination of pipe, but not all of these fittings are stocked in local stores. However, fittings are light and can be shipped anywhere by air. The same is true for lawn sprinkler nozzles and adapters. Plan ahead and order any parts that aren't locally available.

Connecting the pipe and fittings is straightforward for threaded fittings, and slip-together fittings bonded with common PVC pipe cement. These connections are usually made on the ground. The clamped Poly pipe connections are a different matter. Some of the $^{1}/_{2}$-in Poly pipe slips over the "barbed" plastic fittings quite easily, but other samples go on only with difficulty. This difficulty caused concern when the bottom of the rigid pipe and the top of the flexible pipe were connected while workers were leaning out of the bucket in the tree crown.

We recommend heating the Poly pipe slightly with a propane torch just before slipping it over the barbed fitting. Secure it with a worm gear-type hose clamp. With heat, the connection will be more easily made and the pipe will better conform to the inside of the clamp. This is also the reason for using the narrower, $^{5}/_{16}$-in-wide clamp instead of the more common $^{9}/_{16}$-in-wide clamp. The better the connection between the Poly pipe and its fittings, the less likely a problem with leaks.

Terminating the ground-end of the Poly pipe with a fitting having a male garden hose thread allows for convenient, temporary plumbing. If quick-disconnect couplers are not used, the male hose thread can be capped with the plastic screw cap off of most plastic soda-pop bottles to exclude insects and debris. Garden hose quick-disconnect couplers are also available. The halves can be purchased separately. The male half of the coupler can be obtained with female hose threads to connect directly to the poly pipe ground fitting. A plastic cap has been found that fits on the coupler's male half to exclude insects and debris. The minimum purchase was 5,000 caps. While the Center's supply lasts, MTDC will provide these to Forest Service units.

When trees are close together, several single-tree systems can be connected on the ground using common garden hose and wye fittings. The number of systems that can be connected and pumped to at the same time depends on the capacity of the pump. However, hoses could burst if too powerful a pump is used. Manifolding many hose thread outlets at the pump discharge would probably solve this problem. But remember, the more complicated the plumbing, the longer the drainback time.

Final Equipment Configuration

Parts list common to both $^1/_2$-in and $^3/_4$-in systems:

1—Nozzle Rain Bird Sales, Incorporated:
1800 Series Plastic MPR Nozzle
1800-8F, 1.57 gpm, 10-ft radius, full circle, 5° trajectory up
1800-10F, 1.57 gpm, 10-ft radius, full circle, 15° trajectory up
1800-12F, 2.60 gpm, 12-ft radius, full circle
1800-15F, 3.70 gpm, 15-ft radius, full circle
(All nozzles include screens)

1—Rain Bird Sales, Inc. Plastic shrub adapter No. PA-8S

2—Ideal Corp. stainless steel clamps No. 62606, $^7/_8$-in micro clamp

1—$^1/_2$-in Poly flexible pipe, length to clear tree and spray radius

1—Spears insert reducing hose adapter, $^3/_4$ HT x $^1/_2$ INS No. 1436-101 MHT

1—L.R. Nelson Corporation, snap connect faucet-to-hose end connection, Wal-Mart No. WM2975

1—Niagara Plastics Co. EZ pipe cap No. NIAEZ6 - 1AH1

1—Ideal Corp. stainless steel clamp No. 6810-$^3/_4$-in clamp

1—Radio Shack, TV lead-in standoff No. 15-854 ($5^1/_2$ in)

1—Radio Shack, TV lead-in standoff No. 15-853 ($3^1/_2$ in)

1—Common garden hose long enough to easily reach connections at base of tree from tractor-mounted pump

1—L.R. Nelson Corporation snap connect flow control hose end, Wal-Mart No. WM2900

Additional parts for $^1/_2$-in PVC conduit/pipe system:

1—Spears Plastic Pipe Products, $^1/_2$-in Schedule 40 male adapter No. 436-005

1—$^1/_2$-in PVC rigid conduit/pipe, 10-ft length

1—Spears $^1/_2$-in Schedule 40 insert X slip adapter No. 474-005

Or additional parts for alternate $^3/_4$-in PVC conduit/pipe system:

1—Spears Schedule 40 reducing male adapter, $^1/_2$-in IP x $^3/_4$ Slp, No. 436-074

1—$^3/_4$-in PVC rigid conduit/pipe, 10-ft length

Plus either:

1—Spears $^3/_4$-in Schedule 40 female adapter No. 435-007

1—Spears Poly insert male adapter $^3/_4$ IP X $^1/_2$ Ins No. 1436-101

Or:

1—Spears Schedule 40 female adapter reducer, $^3/_4$ Slp X $^1/_2$ Ip No. 435-101

1—Spears $^1/_2$-in Poly insert female adapter No. 1435-005

Or:

1—Spears Schedule 40 reducing male adapter, $^1/_2$ Ip X $^3/_4$ Slp No. 436-074

1—Spears $^1/_2$-in Poly insert female adapter No. 1435-005

References

Herzberg, Diane; Rappaport, Nancy; Pierson, Pat. 1995. Single tree spray systems: progress report. Tech. Rep. 9534-2850-MTDC. Missoula, MT: U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center. 26 p.

Appendix A—Trip Reports

Oconto Seed Orchard

May 22, 1995

Subject: MTDC staff trip to the Oconto Seed Orchard on the Nicolet National Forest, Antigo, Wisconsin

Dates: May 8-12, 1995

Prepared by: Bill Kilroy

Objective: To install single-tree sprayer systems in 40 trees at the Oconto Seed Orchard, based on experience gained at the Coeur d'Alene and Beech Creek orchards installing similar systems.

Contacts:

Bill Sery, *Oconto Seed Tree Orchard Superintendent*
Dan Rolo, *Tractor Operator*
Bill Wesner, *Tractor Operator*
Lin Klapps, *Biological Aid*
April Schreiver, *Biological Technician*

MTDC Participants:

Mike Huey, *MTDC Technician*
Winston Hayden, *MTDC Technician*
Mark Wiggins, *MTDC Photographer*
Bill Kilroy, *MTDC Technician/Writer*

Activities:

On May 8, 1995, Mark Wiggins, Winston Hayden, and Bill Kilroy traveled to Wausau, Wisconsin by air. They were met at the airport by Mike Huey and driven to Antigo, the closest town to the Oconto Seed Orchard. Huey had arrived on site Wednesday, May 3 to assist in the evaluation of another FPM/MTDC project, Thermal Insect Control.

On May 9, Wiggins, Hayden, Huey, and Kilroy arrived at the Orchard at 0730. Bill Sery made a short presentation outlining the Oconto Seed Orchard operation in general, and describing the work that had been done to develop a strain of eastern white pine with a heightened resistance to blister rust. He noted there were 40 trees in his orchard that he had selected for the single tree sprayer evaluation. These trees were from the blister rust resistant group. The spraying was to control the eastern white pine cone beetle.

The day was overcast with intermittent heavy rain and wind, so the decision was made to assemble the plumbing inside, and to travel to Green Bay for some additional parts.

On Wednesday, May 10, and Thursday, May 11, all participants worked in the orchard placing the single-tree spraying equipment in the designated trees. Mark Wiggins took pictures of all phases of the operation before leaving on Thursday.

Sery had two self-propelled man lifts rented for the operation, and though the ground was soft from days of rain, they performed well. Two men went up in each bucket to attach the spray equipment to the tree, while one helper remained on the ground to hand them the pipe. Most of these trees were about 35 ft tall. The nozzles were set 2 ft above the treetops. It took approximately 15 minutes to fasten the rigid piping properly in each tree and to attach the flexible pipe. Much of the time however, was spent repositioning the lifts, as the 40 trees were in groups of four or five spread here and there about the southwest corner of the orchard.

The crew completed installing single-tree spraying systems in 36 of the designated orchard trees, working until 1630 hours each day. The orchard crew said they would have no trouble completing the job on Friday morning.

In testing the system, Sery was satisfied with the volume of spray released and the apparent pattern. The pump pressure was begun at 45 psi, but later was dropped to 30 psi. He was also satisfied with the system drain time of 10 seconds.

Equipment Configuration:

The single-tree sprayer systems installed in the Oconto Orchard trees were configured as follows, progressing from top to bottom: Rain Bird 1800 Series, PF-15 plastic sprinkler nozzle with 15 ft radius, 30 degree trajectory, and 3.7 gpm flow at 30 psig. The basket strainer supplied with the nozzle was used.

The nozzle was screwed into a PA-8S shrub adapter. The shrub adapter was screwed onto a $^1/_2$-in male pipe thread fitting glued to the top of the $^1/_2$-in PVC.

Twenty ft (two 10-ft lengths) of $^1/_2$-in PVC pipe was used. This was gray electrical conduit, chosen because it is UV (ultraviolet) resistant. Since this pipe is designated for use

as conduit, no PSI rating is listed by the manufacturer. A UV-resistant water pipe is designed for outside use. This pipe however, is not readily available and it is more expensive. White PVC couplings were used because they were readily available.

The PVC was fastened to the tree with two "TV antenna lead-in standoffs." These are standard Radio Shack items and are used without the center plastic insert. The $3^1/_2$-in standoff is catalog Number 15-853, and the $5^1/_2$-in standoff is catalog Number 15-854. A hose clamp was positioned above the standoffs to keep the pipe from slipping down. Depending on the diameter of the tree stem at the top, a plastic tie was sometimes substituted for the top standoff.

A $^1/_2$-in female pipe thread fitting was glued to the bottom of the PVC pipe, and a $^1/_2$-in male pipe thread to $^1/_2$-in hose barb fitting was screwed into the female fitting.

Fifty ft of $^1/_2$-in polyethylene 100 psi utility (flexible) pipe was pressed onto the hose barb and secured with a hose clamp.

On the bottom (ground) end, a $^1/_2$-in male pipe thread to $^1/_2$-in hose barb fitting was pressed on and secured with a hose clamp.

A $^1/_2$-in female pipe thread to $^1/_2$-in female hose adapter (with washer) was screwed onto the hose barb fitting to complete the assembly. This was taped over to keep insects and debris out of the system.

A replaceable cartridge "whole house"-type water filter with a rating of 4 gpm flow at 120 psi was installed between the tree sprinkler systems and the tractor-driven pump at the pump discharge.

The Rain Bird 1800 series "pop up" sprinkler head was not used at the Oconto Seed Orchard. Using a PA-8S shrub adapter makes a less expensive and cleaner system with less wind resistance at the top of the tree.

Because of slow drainback at the Beech Creek Seed Orchard, a T-fitting was installed in many of the Oconto systems. This fitting was located at the top of the 20-ft PVC pipe, below the strainer and nozzle. The fitting was installed to place a check valve at the top of the plumbing column, venting the system during the draining process. It was thought that this would solve the "slow drainback" problem. Only one check valve was available at Oconto for testing. All the other T-fittings were plugged after the test results were evaluated.

In testing the systems at Oconto, there was no difference in the drainback time between systems equipped with a check valve and those without. At Oconto, the complete system could be drained by gravity in 10 seconds. Therefore, the T-fitting and check valve appeared to be unnecessary. A valve should be installed to isolate the tank and bypass the filter when draining the system. What appeared to be an excessively long drainback time was really caused by water that was being siphoned out of the tank. Once this was realized, and plumbing changes made, drainback took just 10 seconds.

Because the hose-clamped joints in the Beech Creek installations leaked, narrower clamps and heated joints were tried in the Oconto installation. The narrower, $^5/_{16}$-in clamps (Ideal Number 62606) were used with both heated and unheated Poly pipe on some systems. Standard $^9/_{16}$-in clamps (Ideal Number 6810) were used with heated Poly pipe on other systems.

In Conclusion:

At this time it would appear that the $^1/_2$-in gray PVC electrical conduit is as rigid as $^1/_2$-in Schedule 40 white PVC, and can be used to avoid sunlight degradation.

As was mentioned in the Beech Creek report, the pop up sprinkler heads are unnecessary, and should be replaced with the PA-8S shrub adapter.

No excessive drainback delays were experienced with the PA-8S adapters, strainers, and Number 15F nozzles.

Whether $^5/_{16}$-in or $^9/_{16}$-in hose clamps are used, the Poly pipe should be warmed with a propane torch just before assembly. Locate the clamp around the smooth part of the hose barb fitting, above the barb and near the end of the pipe. Either clamp will provide a tight joint with heated pipe. The wider clamp deforms the pipe and fitting somewhat more, but is less likely to be stripped in tightening. Heating the pipe also makes for easier assembly when you are leaning from the lift bucket in the tree crown.

On the bottom (ground end) of the polyethylene pipe, female hose end fittings were used in the Oconto Orchard instead of the male hose end fittings that were used at Beech Creek. This was done to facilitate the use of inexpensive plastic quick-disconnect hose couplers. The least expensive setup, and the most easily closed to bugs

and debris, would be one that had a male hose thread fitting on the bottom end of the polyethylene pipe onto which is screwed a female hose-to-male quick-disconnect fitting (Wal-Mart "Good Housekeeping" Stock Number WM2975). Putting the male half of the quick-disconnect fitting in this position enables it to be easily taped over, or sealed with a plastic cap. The female half of the quick-disconnect coupling can be either the shutoff type with female hose thread (part of Wal-Mart "Good Housekeeping" Stock Number WM2900), or the normal female half of the coupling (part of Wal-Mart "Good Housekeeping" Stock Number WM2970), with male hose thread, used in conjunction with a female hose to female hose adapter on the hose from the pump. These fittings are available through Wal-Mart and are manufactured by Nelson. Also, we have requested information and samples of plastic caps. We will recommend a part that might be used to cover the fitting at the base of each tree (instead of tape) as soon as we find the right cap or plug.

—Bill Kilroy, *Mechanical Engineering Technician*

Coeur d'Alene and Beech Creek Seed Orchards

Subject: MTDC staff visits to the Coeur d'Alene, ID, and Murphy, NC, seed tree orchards

Dates: March 8 and 13-17, 1995

Prepared by: Dave Rising

Objective: To learn about the sprinkler systems installed in Coeur d'Alene in 1994, and then to use this information while installing similar systems in the Beech Creek Seed Orchard in Murphy, NC.

Contacts:

Sandie Kegley, *USDA-FS Coeur d'Alene Field Office, Coeur d'Alene, ID*
Joe Myers, *Nursery Superintendent, USDA-FS Coeur d'Alene Nursery, Coeur d'Alene, ID*
Steve Ausbon, *Weyerhaeuser Co., Washington, NC*
Larry Barber, *USDA-FS SEFES, Forest Health, Asheville, NC*
Darlene Barrett, *USDA-FS SEFES, Forest Health, Asheville, NC*
Glen Beaver, *Orchard Manager, USDA-FS Beech Creek Seed Orchard, Murphy, NC*
Michael Cody, *USDA-FS SE Station, Forestry Sciences Laboratory, Athens, GA*
Christopher Crowe, *USDA-FS SE Station, Forestry Sciences Laboratory, Athens, GA*
Gary DeBarr, *USDA-FS SE Station, Forestry Sciences Laboratory, Athens, GA*
Joe Jarman, *Weyerhaeuser Company, Trenton, NC*
Clay Logan, *USDA-FS Beech Creek Seed Orchard, Murphy, NC*
Robin Taylor, *USDA-FS Beech Creek Seed Orchard, Murphy, NC*
Windy Hayden, *USDA-FS Technology and Development Center, Missoula, MT*
Mike Huey, *USDA-FS Technology and Development Center, Missoula, MT*
Bill Kilroy, *USDA-FS Technology and Development Center, Missoula, MT*
Dave Rising, *USDA-FS Technology and Development Center, Missoula, MT*
Mark Wiggins, *USDA-FS Technology and Development Center, Missoula, MT*

Activities:

On 3-8-95, the above five MTDC personnel traveled to the Coeur d'Alene Nursery in Coeur d'Alene, ID, where they and Sandie Kegley and Joe Myers looked at and discussed last year's sprinkler installations. The purpose of this trip was to familiarize MTDC technicians with what Diane Herzberg had done there so that they could repeat the installation in Murphy, NC.

On 3-13-95, Hayden, Huey, Rising, and Wiggins traveled to Murphy, NC.

On 3-14-95, all of the above people except Kegley, Myers, and Kilroy met at the Nantahala National Forest, Tusquitee Ranger District offices in Murphy. MTDC personnel brought all the sprinklers and fittings necessary to duplicate the Coeur d'Alene installation in Murphy, except for the rigid and flexible plastic pipe. After meeting in the morning, people split up into several groups, did some shopping for supplies, and met in the field at the Beech Creek Seed Orchard a few miles outside of Murphy that afternoon. Sprinklers were placed in two 50- to 55-ft tall trees using the truck-mounted lift provided by Larry Barber. Each system used a Rain Bird 1803 pop-up sprinkler head with XS-360 Xeri-Spray nozzle and XBA-1800 adapter. One

was at the top of an 8 1/2-ft piece of 1/2-in EMT steel electrical conduit, and the other was at the top of a 10-ft piece of 1/2-in Schedule 40 rigid plastic pipe (plastic conduit was actually used). One 80-ft length of 1/2-in, 125 psi flexible plastic pipe was connected to the bottom of the vertical EMT or rigid plastic pipe in each treetop, and fed through the branches to the ground near the trunk of an adjacent tree. When a tractor-mounted, PTO-driven pump belonging to the orchard was connected to one of the spray systems, it was determined that the approximate 0.5- to 0.6-gpm flow available through the XS-360 nozzle (wide open) was inadequate to do what Larry Barber wanted done. We next tried a 8F-FLT nozzle; the approximate 1.5- to 1.6-gpm flow was still inadequate. The day ended with a call being placed to Missoula and additional nozzles being sent by Fed Ex.

On 3-15-95, additional supplies were purchased in the morning, the nozzles were delivered at noon, and testing was performed in the orchard in the early afternoon. The 12F and 15F full circle nozzles were tested. Although the 12F had a flow of approximately 2.6 gpm, the 15F with a flow of approximately 3.7 gpm was judged to be the best choice to install in quantity. The first two systems were removed (8 1/2-ft EMT and 10-ft rigid plastic). By the end of the day, seven systems using 20-ft lengths of either 1/2-in or 3/4-in Schedule 40 rigid plastic pipe and 80-ft lengths of 1/2-in flexible plastic pipe were installed.

On 3-16-95, it was decided to install 18 systems instead of the originally requested 14 because 18 sets of sprinklers, nozzles, and fittings had been supplied by MTDC. However, only 11 lengths of 1/2-in Schedule 40 pipe were available. Seven sets were made using 3/4-in Schedule 40 pipe. By the way, the only Schedule 80 rigid plastic pipe available in Murphy were some dark gray 20-ft lengths of 1/2-in pipe that seemed to be possibly less rigid than the white Schedule 40 pipe. A total of 18 systems were made up by the end of the day, and 14 of those were installed in trees when the MTDC crew left the orchard.

As was mentioned earlier, testing was done using a tractor-mounted, PTO-driven pump with attached plastic tank, plumbing, valve and pressure gauge. The outlet after the valve had a hose thread and we installed several more feet of hose before attaching an in-line filter. It was felt that even with the small plastic strainers provided with each nozzle installed, it would be a good idea to keep material from entering the piping should a pump fail, etc. A length of garden hose was used between the filter and the 80-ft length of 1/2-in flexible pipe coming down each tree.

Notes were taken of the typical installations with the two different sizes of pipe for a report to be prepared on this project. Black-and-white pictures, color slides, and video footage were shot during the several days in Murphy. The video footage will be edited into a short segment and will be available to anyone interested in putting sprinklers in the tops of trees. Larry Barber, Glen Beaver, and the rest of the people working in the orchard have been using the sprinklers and are continuing to find better ways of doing things. Their results will be forthcoming in subsequent memos.

One additional subject should be discussed. When we went to Murphy, it was our intent to start out by duplicating the systems installed in Coeur d'Alene. In hindsight, it would seem to be easier, cheaper, and more straightforward to skip the pop-up sprinkler bodies and use Rain Bird PA-8S Plastic Shrub Adapters instead. These have the same 1/2-in FPT thread on the "bottom," the male thread onto which the nozzles screw on the "top," and will accept the nozzle strainers. This information was faxed to Steve Ausbon of Weyerhaeuser Company because he is planning to install similar systems in more than 200 trees as soon as possible. Larry Barber may also be planning on trying some sprinkler systems without pop-up heads in the Beech Creek Seed Orchard.

—Dave Rising, *Mechanical Engineer*

Appendix B—Hose Diagram

1—Nozzle Rain Bird Sales, Inc.:
- 1800 Series plastic MPR nozzle
- 1800-8F, 1.57 gpm, 10-ft radius, full circle, 5° trajectory up
- 1800-10F, 1.57 gpm, 10-ft radius, full circle, 15° trajectory up
- 1800-12F, 2.60 gpm, 12-ft radius, full circle
- 1800-15F, 3.70 gpm, 15-ft radius, full circle

(All nozzles include screens)

3—Spears Schedule 40 reducing male adapter, $^{1}/_{2}$ in IP x $^{3}/_{4}$ Slp, No. 436-074

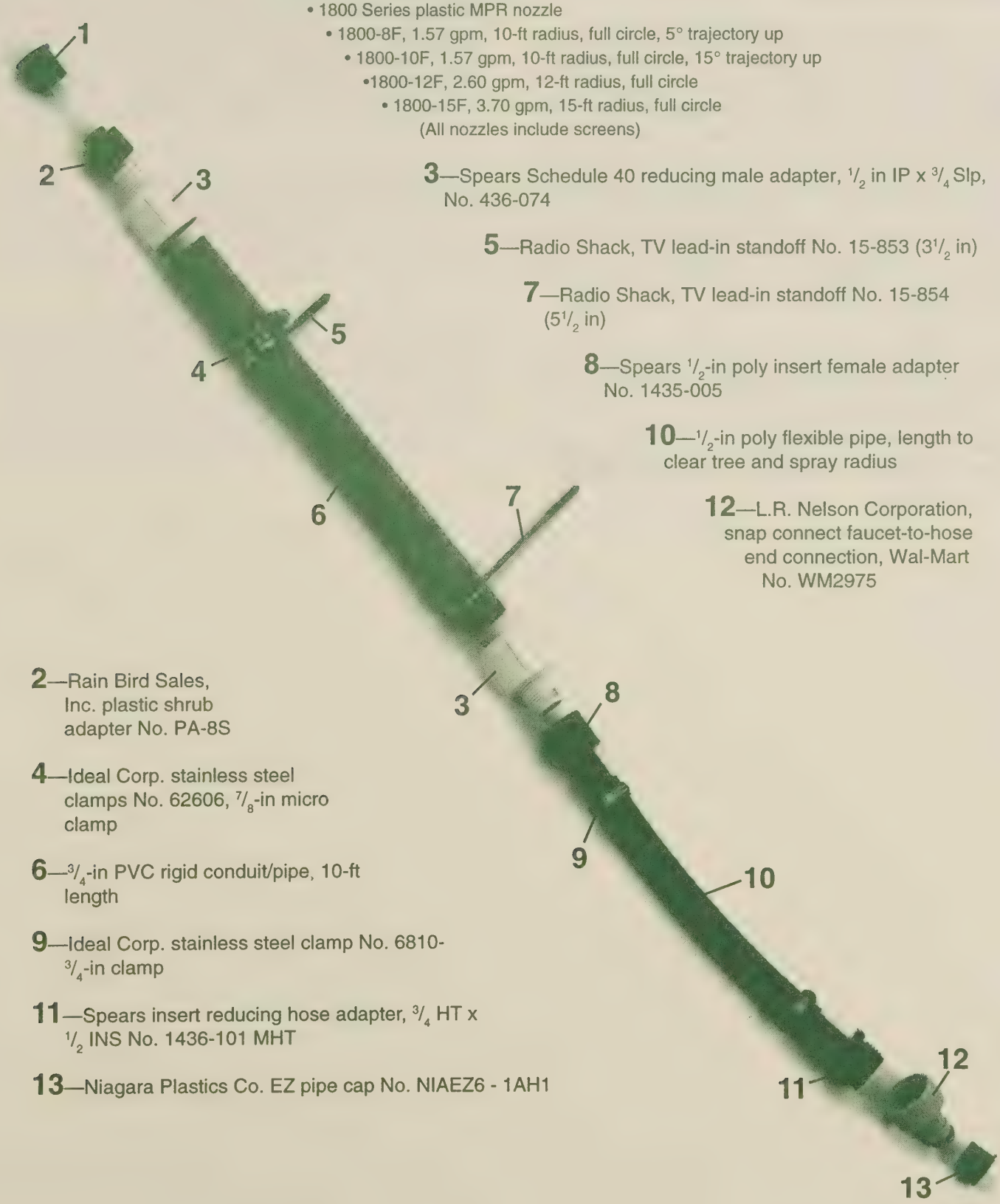
5—Radio Shack, TV lead-in standoff No. 15-853 ($3^{1}/_{2}$ in)

7—Radio Shack, TV lead-in standoff No. 15-854 ($5^{1}/_{2}$ in)

8—Spears $^{1}/_{2}$-in poly insert female adapter No. 1435-005

10—$^{1}/_{2}$-in poly flexible pipe, length to clear tree and spray radius

12—L.R. Nelson Corporation, snap connect faucet-to-hose end connection, Wal-Mart No. WM2975



2—Rain Bird Sales, Inc. plastic shrub adapter No. PA-8S

4—Ideal Corp. stainless steel clamps No. 62606, $^{7}/_{8}$-in micro clamp

6—$^{3}/_{4}$-in PVC rigid conduit/pipe, 10-ft length

9—Ideal Corp. stainless steel clamp No. 6810-$^{3}/_{4}$-in clamp

11—Spears insert reducing hose adapter, $^{3}/_{4}$ HT x $^{1}/_{2}$ INS No. 1436-101 MHT

13—Niagara Plastics Co. EZ pipe cap No. NIAEZ6 - 1AH1

Appendix C—Bill Sery's Oconto River Seed Orchard Report

Aerial Sprinklers

Aerial sprinkler systems were installed in 40 trees in the eastern white pine breeding arboretum at Oconto River Seed Orchard in the spring of 1995 with the help of Missoula Technology Development Center. Trees were selected on the basis of 1) being part of a breeding program, 2) needing seed to develop new orchards, or 3) having frequent seed requests from researchers at North Central Experiment Station. Past efforts at breeding and collecting seed from these trees had been dismal because of severe damage caused by the white pine cone beetle, *Conophthorus coniperda*; and the white pine cone borer, *Eucosma tocullionana*.

The basic design, used at other orchards, was followed with a few minor modifications. Gray PVC electrical conduit was used instead of standard PVC because of its superior resistance to ultraviolet degradation. The gray PVC was also tested for breakage. It was noted to take a larger blow to break it. However, when it did break, it broke into more pieces. It was hoped that the greater strength would lead to greater resistance to wind breakage. A check valve on a tee, located near the top, was also tried to alleviate some of the drain-down problems experienced at Beech Creek Orchard in North Carolina. When it was discovered that drain-down was not a problem, the check valve was eliminated.

Three applications of Asana XL were made in 1995 and three in 1996. 9.6 ounces of Asana XL were diluted in 100 gallons of water. Then 10 gallons spray solution were applied to each tree. The process was rather time consuming, requiring 1–1.5 days per application.

The results look encouraging. Only minimal winter damage was sustained during a very tough winter. Infestation tallies performed in 1995 showed an improvement in sprayed versus non-sprayed trees. This year we are looking forward to harvesting a significant cone crop from treated trees whereas previously we had met with much frustration.

Notes

Additional single copies of this document may be ordered from:

USDA Forest Service, MTDC
Building 1, Fort Missoula
Missoula, MT 59804-7294
Phone: (406) 329-3900
Fax: (406) 329-3719

For further technical information, contact Bill Kilroy at the address above.

Phone: (406) 329-3925
Fax: (406) 329-3719
DG: W.Kilroy:R01A
E-mail: /s=w.kilroy/ou1=r01a@mhs-fswa.attmail.com

Library Card

Kilroy, Bill; Rising, Dave. 1996. Single-tree spray application project: final report. Tech Rep. 9634-2838-MTDC. Missoula, MT: U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center. 14 p.

Describes the use of sprinkler heads in the tops of trees to apply insecticide to a single tree. This technique can be used in seed tree orchards to protect valuable trees while minimizing the amount of insecticide applied in the orchard.

Keywords: insecticides, orchards, spraying equipment.